Test-retest reliability of the 300-yard Shuttle Run Test

Hanna Gottlieb

Bachelor thesis in Exercise Biomedicine, 15 credits

Halmstad 2015-05-25
Test-retest reliability of the 300-yard Shuttle Run Test

Hanna Gottlieb

2015-05-25
Bachelor Thesis 15 credits in Exercise Biomedicine
Halmstad University
School of Business, Engineering and Science

Thesis supervisor: Hanneke Boon
Thesis examiner: Ann Bremander
Acknowledgements

I would like to thank friends and family for their support during the writing of this thesis. A special thanks to Erik Lindqvist, Christoffer Sundell, Frida Linderoth, Mathias Warnström, Frida Elmdahl and Emmelie Akesten for their invaluable help during test sessions. I would also like to thank Jonathan Larsson for all his help with logistics and scheduling and all the participating test subjects. And last but not least, my thesis advisor, Hanneke Boon for her feedback and advice as well as my examiner Ann Bremander for her advise and concrete examination.
Abstract

**Background:** Several field-based team sports contain repeated, maximal effort sprints with varying rest lengths in between. This puts high demands on athletes’ metabolic and neuromuscular systems. Testing the anaerobic capacity of athletes is essential to improve and evaluate the progression. One test being utilised for assessing anaerobic capacity is the 300-yard shuttle run test. The test is field-based with stopwatches as the sole equipment. However, the test has not been properly tested for reliability.

**Aim:** The aim of this bachelor thesis was therefore to investigate the reliability of the 300-yard shuttle run test. **Methods:** The study was performed with a test-retest method and included a familiarisation meeting, test session and retest session. Test subjects performed the 300-yard shuttle run test at two different occasions with seven or fourteen days in between. The intraclass correlation coefficient (ICC) and 95% confidence interval (CI) was utilised to quantify the reliability. An ICC>0.8 was considered acceptable. **Results:** 17 American football players participated in the study (median age 20, min. =18, max. =38 y; median weight 83, min. =67, max. =133 kg; median height 184, min. =169, max. =194 cm). The ICC for the test-retest was 0.97 (95% CI 0.91-0.99). **Conclusion:** Based on the results of this study 300-yard shuttle test is proposed as a test providing reliable results.
# Table of Contents

**Introduction**  
1

**Background**  
1
  Neuromuscular demands during repeated sprints  
4
  Practical Applications  
6
  Testing anaerobic capacity  
6
  The 300-yard shuttle run test  
7
  Reliability and previous use of the 300-yard shuttle run test  
8
  Assessment of reliability  
9
  Aim  
9

**Method**  
10
  Subjects  
10
  Test Procedure  
10
  Equipment and material  
12
  Ethical and Social considerations  
12
  Statistical analyses  
12

**Results**  
13

**Discussion**  
14
  Result discussion  
14
    Previous studies reliability testing repeated sprint ability tests  
15
    Within-subject variation  
16
  Method discussion  
17

**Conclusion**  
19

**References**  
21

**Appendix 1. Informed Consent form**  
24
Introduction

Several field-based team sports contain repeated, maximal effort sprints with varying rest lengths in between. Maintaining high performance throughout a match puts high demands on the anaerobic and aerobic capacity of the athletes (Gilliam & Marks, 1983; Glaister, 2005; Girard, Mendez-Villanueva, & Bishop, 2011; Baechle & Earle, 2008). Developing an understanding of the different physical systems determining performance is important in order to design an intervention program aiming to improve the different qualities of the athletes. Testing physical capacity is the next step in order to follow the development of the athletes and evaluate the intervention program (Girard, Mendez-Villanueva, & Bishop, 2011).

One test being utilised for assessing anaerobic capacity is the 300-yard shuttle run test. The test is supposed to mimic the physical demands of an American football match, containing two bouts of repeated sprints (Gilliam & Marks, 1983). The test is field-based with stopwatches as the sole equipment. This enables any team and athlete to use the test, without access to laboratory equipment. The 300-yard shuttle run test has been utilised by a few studies to assess anaerobic capacity of test subjects. However the test has not been tested properly for reliability. Therefore the aim of this study is to investigate the reliability of the 300-yard shuttle run test.

Background

Many team sports contain repeated, short duration, high intensity sprints (Gilliam & Marks, 1983; Glaister, 2005; Girard, Mendez-Villanueva, & Bishop, 2011; Baechle & Earle, 2008). When investigating intermittent sprint training in a laboratory environment, the intermittent sprints have shown to cause decreased peak sprint speed, power output, maximal voluntary contraction (MVC) and jump height (Girard, Mendez-Villanueva, & Bishop, 2011; Duffield & Minett, 2014; Morcillo et al., 2014). Observations of performance reduction in field-based environments are more ambiguous. When performing time-motion analyses of team sport athletes, an episodic work rate reduction after maximal efforts was highlighted as well as a progressive decline in total distance covered in a certain amount of time (Duffield & Minett, 2014).
The prolonged intermittent-sprint exercises during training and match play puts high demands on the physiological, neuromuscular and perceptual systems (Duffield & Minett, 2014). In the next section, the metabolic and neuromuscular systems are explained in more detail. A deep insight of how these systems work and are influenced by intermittent-sprint exercises is essential in order to interpret the result of the 300-yard shuttle run test and understand the physical qualities needed to improve the test results.

**Metabolic demands and fatigue during repeated sprints**

Fatigue is defined as a decrease in force and velocity, which will results in reduced muscle power (Fitts, 2008). Fatigue induced by repeated sprint exercise (RSE) is a large area of research (Girard, Mendez-Villanueva, & Bishop, 2011) and there are today several hypotheses for the cause of peripheral fatigue (Baechle & Earle, 2008). Following section will describe the theorised factors causing fatigue during RSE.

Adenosine triphosphate (ATP) is the energy supplier for several important reactions and processes within muscle cells. Such as the calcium ion (Ca$^{2+}$) release channels on the sarcoplasmatic reticulum (SR), the sodium-potassium (Na$^+$-K$^+$) pumps over the sarcolemma and the myosin-actin cross-bridge cycles representing muscle fibre contraction. ATP hydrolysis results in adenosine diphosphate (ADP) and inorganic phosphate (Pi) accumulation (Allen, Lamb, & Westerblad, 2007; McArdle, Katch, & Katch, 2010; Girard, Mendez-Villanueva, & Bishop, 2011).

The Pi accumulation seems to affect muscle function by inhibiting myofibrillar Ca$^{2+}$ sensitivity and cross-bridge detachment resulting in less optimal myofibrillar force production (Glaister, 2005; Girard, Mendez-Villanueva, & Bishop, 2011; Allen, Lamb, & Westerblad, 2007; Fitts, 2008). High concentrations of Pi also seem to inhibit the SR Ca$^{2+}$ release channels and the precipitation of CaPi to free Ca$^{2+}$ and Pi within the SR, decreasing the amount of free Ca$^{2+}$ in the mycoplasma (Allen, Lamb, & Westerblad, 2007). Thus the muscle contractility is greatly affected because of the actin-myosin cross-bridge cycle being dependent of free Ca$^{2+}$ in order for myosin to bind to actin (McArdle, Katch, & Katch, 2010).
Muscles fibres performing intense exercise consume ATP faster than it is regenerated aerobically, thus in order to maintain adequate levels of ATP other anaerobic energy pathways are used. Intramuscular phosphocreatine (PCr) is the initial source for ATP regeneration. PCr reacts with ADP and a hydrogen ion ($H^+$) resulting in ATP regeneration (McArdle, Katch, & Katch, 2010; Allen, Lamb, & Westerblad, 2007; Glaister, 2005). After 6 seconds of maximal work the PCr stores are halved compared with resting levels (Girard, Mendez-Villanueva, & Bishop, 2011; Duffield & Minett, 2014) and after 10 seconds the stores are largely depleted (Glaister, 2005). Complete PCr storage restoration is estimated to take approximately 5 minutes or more and is achieved only in aerobic conditions (Girard, Mendez-Villanueva, & Bishop, 2011; Glaister, 2005).

The anaerobic glycolysis is also used to regenerate ATP during maximal efforts, rising $H^+$ and lactate accumulation (Girard, Mendez-Villanueva, & Bishop, 2011; Glaister, 2005; Duffield & Minett, 2014; Allen, Lamb, & Westerblad, 2007; Allen, Lamb, & Westerblad, 2007). Firstly the anaerobic breakdown of glucose to pyruvate is conducted within the cytoplasm. During rapid anaerobic glycolysis lactate is formed by combining pyruvate with $H^+$ in the lactate dehydrogenase reaction, enabling fast NAD$^+$ regeneration from NADH which is essential for continued glycolysis (McArdle, Katch, & Katch, 2010). The anaerobic glycolysis conducts about 40% of ATP regeneration during 6 seconds of maximal work with a progressive inhibition as sprints are repeated (Girard, Mendez-Villanueva, & Bishop, 2011). After a team sport competition a 25-55% glycogen store depletion is expected in working muscles, which contributes to the decline in sprint times. The glycogen depletion takes 2-3 days to restore depending on magnitude of the depletion, post-exercise recovery and nutrition (Duffield & Minett, 2014).

The pH drop (<6.7) has a potential role in reduced muscle power. It can cause glycolytic impairments because of $H^+$ inhibiting effect on glycolysis and glycogenolysis regulatory enzymes (Glaister, 2005; Girard, Mendez-Villanueva, & Bishop, 2011; Fitts, 2008). The $H^+$ accumulation also affects rate and force of the cross-bridge cycle. Presumably by slowing down the ADP release from myosin, which is the final step of the cross-bridge cycle followed by a new ATP molecule binding, enabling filaments to continue muscle contraction movements (Fitts, 2008).
The adenylate kinase reaction (ADK) is initiated if ADP reaches high enough local concentration. Two ADP molecules react resulting in one ATP and one adenosine monophosphate (AMP) molecule (Glaister, 2005; Allen, Lamb, & Westerblad, 2007; McArdle, Katch, & Katch, 2010). AMP can be further deaminated resulting in accumulation of inosine monophosphate (IMP) and ammonia. The accumulation of ADP, AMP and IMP is associated with fatigue during intermittent sprint work, which is in line with the idea that muscular fatigue is due to failure of the metabolic pathways to resynthesize ATP (Glaister, 2005). Most ATP molecules have magnesium ions (Mg^{2+}) bound. ADP, AMP and IMP have a much lower affinity to Mg^{2+} so when ATP concentrations are decreased during intense exercise, the concentration of free Mg^{2+} within fibres are increased. Mg^{2+} has an inhibiting affect on Ca^{2+} release from SR (Allen, Lamb, & Westerblad, 2007).

The final energy supplier to the multiple sprint work is the aerobic ATP resynthesis (Glaister, 2005). The aerobic metabolisms contribution during short bouts of maximal work is estimated to represent 10% of the total ATP production during the first 6 seconds of a 10 second sprint with a increasing energy supply contribution as sprints are repeated to as much as 40% (Girard, Mendez-Villanueva, & Bishop, 2011). It seems that the major role of the aerobic system lies in the restoration of homeostasis during recovery periods of intermittent sprint exercises (Glaister, 2005).

To summarise, intense exercise such as repeated sprints elevates ATP use over ATP production. The need for rapid ATP production results in ATP resynthesis through intramuscular PCr, anaerobic glycolysis, aerobic ATP resynthesis and eventually the ADK reaction. During prolonged intense exercise the intramuscular ATP concentrations may be depleted with a concurrent increase of ADP, AMP and IMP level. The intramuscular concentrations of lactate, H^+, P_i and Mg^{2+} are also increased which are factors proposed to contribute to fatigue.

**Neuromuscular demands during repeated sprints**

The process of muscle fibre activation, contraction and relaxation is initiated with an action potential (AP) at the motor neuron resulting in acetylcholine (ACh) release from the vesicles in the terminal axons. ACh diffuses over the synaptic cleft reaching ACh
receptors on the sarcolemma, creating a depolarisation that travels from the sarcolemma to the transverse tubules (T-tubules) system and further in to the muscle fibres. This starts the contractile machinery by stimulating Ca\(^{2+}\) release from the SR, enabling the actin-myosin cross-bridge cycle to start (McArdle, Katch, & Katch, 2010; McKenna, Bangsbo, & Renaud, 2007).

Each AP is created when the threshold for excitation is reached by sodium ion (Na\(^{+}\)) influx and potassium ion (K\(^{+}\)) efflux, causing depolarisation. Repolarisation is achieved by K\(^{+}\) efflux and chloride ion (Cl\(^{-}\)) diffusion in to SR (McArdle, Katch, & Katch, 2010; McKenna, Bangsbo, & Renaud, 2007). Intense exercise causes perturbations of the intra- and extracellular Na\(^{+}\) and K\(^{+}\) concentrations by elevating intracellular Na\(^{+}\) and extracellular K\(^{+}\) as well as lowering extracellular Na\(^{+}\) and intracellular K\(^{+}\) concentrations. How Cl\(^{-}\) is affected by exercise has to be further investigated. Today little changes, intra- and extracellular have been observed but an extracellular decrease and intracellular increase in Cl\(^{-}\) concentrations can be anticipated. The changes in intra- and extracellular concentrations of K\(^{+}\) and Na\(^{+}\) seem to affect muscle contractility. At first the elevation of extracellular K\(^{+}\) and intracellular Na\(^{+}\) concentrations increase tetanic force at submaximal levels. Depressing effects are thereafter found when extracellular K\(^{+}\) reaches a critical concentration resulting in rapid declines of peak tetanic force. (McKenna, Bangsbo, & Renaud, 2007).

Perturbed membrane excitability and muscle fibre contractility might have a role in the decreased performance of repeated sprints. Electromyography (EMG) studies have shown insufficient motor unit recruitment and decreased firing rate when fatigue levels are substantial, resulting in decreased MVC (Girard, Mendez-Villanueva, & Bishop, 2011; Duffield & Minett, 2014). When investigating knee extensor MVC after performing ten 30-second cycle sprints with 30 seconds rest in-between, motor unit activity was still decreased up to 24 hours after sprinting (Duffield & Minett, 2014). The decreased muscle activation also seems to influence sensorimotor control, which may result in increasing risk of injury and decrease in specific sport skill (Girard, Mendez-Villanueva, & Bishop, 2011). The ability to produce maximal force and the technical ability to produce a horizontal force during sprint acceleration is shown to decrease as sprints are repeated with insufficient rest in between (Brocherie, Girard, & Gregorie, 2015).
Practical Applications

From the literature on fatigue mechanisms as reviewed above, it is clear that training to improve aerobic and anaerobic capacity is essential for sports where intermittent sprint performance is important. An enhanced aerobic fitness affects intermittent sprint performance by improving the aerobic contribution to ATP resynthesis, elevating the rate of PCr resynthesis during rest periods and also reducing the accumulation of P_i and H^+ (Glaister, 2005; Girard, Mendez-Villanueva, & Bishop, 2011; Brocherie, Girard, & Gregorie, 2015; Brocherie, Girard, & Gregorie, 2015). A greater ability to recover from a maximal sprint can be essential for the outcome of a game. An impairment of approximately 0.8% can for example, have a crucial effect on the fallout when two opponents are sprinting for the ball in soccer (Girard, Mendez-Villanueva, & Bishop, 2011).

An improved anaerobic capacity increases resting levels of anaerobic energy suppliers such as ATP, PCr and glycogen. It also increases the activity and quantity of enzymes controlling the anaerobic phase of glucose catabolism and the ability to clear high levels of lactate during maximal efforts (Girard, Mendez-Villanueva, & Bishop, 2011; McArdle, Katch, & Katch, 2010; Glaister, 2005). Therefore, raising a better understanding for the different factors causing fatigue is the first step in order to design interventions and tests with the intention to develop, test and improve multiple sprint ability. Assessing the development of athletes using different tests should also be stressed, in order to evaluate the progression of athletes as well as the intervention program (Girard, Mendez-Villanueva, & Bishop, 2011).

Testing anaerobic capacity

Several different tests are available for accessing anaerobic capacity and can be used to assess the development of athletes and evaluate interventions (Brocherie, Girard, & Gregorie, 2015). The Wingate test is a cycle-ergometer all-out test that takes 30 seconds to perform. The test determines peak power and mean power and can also be used to assess explosive power (Popadic Gacesa, Barak, & Grujic, 2009) and calculate a fatigue index (Meckel, Machnai, & Eliakim, 2009). The Wingate test demands laboratory equipment and may have limited application to team sports (Brocherie, Girard, & Gregorie, 2015). For that reason, repeated sprint ability (RSA) tests that are field-based
can be beneficial. These are supposed to produce physiological responses similar to those occurring during intense periods of team sport matches and do not require laboratory equipment (Morcillo, Cuadrado, Jiménez-Reyes, Ortega-Becerra, Emilio, & Párraga, 2014).

A high correlation has been identified between RSA testing protocols, 10-60 meter running sprints and the Wingate test (Morcillo et al., 2014; Wadley & Rossignol, 1998). RSA protocols can differ in sprint length, quantity and rest period between each bout. Common variables determined in these protocols are fastest sprint time, total accumulated sprinting time and performance decrement (Meckel, Machnai, & Eliakim, 2009; Morcillo et al., 2014) The 300-yard shuttle run test is a type of RSA test and is further discussed in following section.

**The 300-yard shuttle run test**

The 300-yard shuttle run test was first described in 1983 by Gilliam G.M. and Marks M. in the National Strength and Conditioning Journal and is still being used as a test to measure anaerobic capacity (Semenick, 1984; Baechle & Earle, 2008). The 300-yard shuttle run test is supposed to simulate an actual American football game with short, fast sprints and changes of direction (Gilliam & Marks, 1983). Sprints performed in a match of a team sport, such as soccer are shorter than 25 yards. Thus, repeated maximal sprints are sometimes required (Sporis, Ruzic, & Leko, 2008), and an efficient ability to recover after a maximal sprint might increase the athletes performance level (Pincivero & Bompa, 1997). Therefore, an improvement in the 300-yard shuttle run test can be a suitable test for anaerobic performance assessment of team sport players (Sporis, Ruzic, & Leko, 2008).

The 300-yard shuttle run test puts high demands on the anaerobic metabolism during sprints as well as the aerobic system during rest periods to restore the homeostasis of the intramuscular environment. One 300-yard bout takes approximately 60 seconds to complete (Baechle & Earle, 2008). An efficient anaerobic metabolism will be demonstrated through fast initial sprint times, high PCr depletion, H⁺ and lactate accumulation (Glaister, 2005; Girard, Mendez-Villanueva, & Bishop, 2011). During the 5 minute rest the aerobic fitness of the athlete will determine the rate of intramuscular
restoration (Glaister, 2005). If recovery is insufficient, performance in the second bout of 300-yards will be deteriorated in comparison to the first. The mean value of the two performed bouts constitutes the result of the 300-yard shuttle run test. Thus, an effective ability to restore the intramuscular environment, which will enable a sufficient performance in the second bout, is of importance.

Reliability and previous use of the 300-yard shuttle run test

The 300-yard shuttle run test has previously been used in studies to evaluate training interventions and physiological factors that determine anaerobic performance. Following section will present all studies found using the 300-yard shuttle run test.

Collins, Silberlicht, Perzinski, Smith, & Davidson (2014) investigated the relationship between body composition and performance in aerobic and anaerobic tests in 54 collegiate male lacrosse players. They used several tests to measure different skills and used the 300-yard shuttle run test to estimate anaerobic conditioning. A positive correlation between body fat and performance in 300-yard shuttle run test was reported (Collins, Silberlicht, Perzinski, Smith, & Davidson, 2014).

Sporis, Ruzic, & Leko (2008) evaluated an 8-week intervention program containing a specific sprint drill designed to improve acceleration, maximal speed and agility. 18 male soccer players, all members of the First league team, participated in the study. The study was divided in two phases. In phase 1 in year 2002 the soccer players performed the 300-yard shuttle run test as initial testing one week prior to the beginning of the standard pre-season conditioning and then once more, eight weeks later in the end of the pre-season. No significant difference was observed between the two test sessions. Thereafter phase 2 started in 2003 with the 300-yard shuttle run test as initial testing one week prior to the beginning of the pre-season conditioning and then once more in the end of the pre-season. This time the soccer players performed specific sprint drills and an improvement in 300-yard shuttle run test was observed (Sporis, Ruzic, & Leko, 2008). Sporis, Ruzic, & Leko (2008) also claim to have reliability tested the 300-yard shuttle run test through a test-retest method. However, an eight week intervention, aiming for physical adaptations was conducted between the test and retest sessions.
This contradicts with the typical method of a reliability test (Thomas, Nelson, & Silverman, 2011).

Sport coaches who currently are or are not using the 300-yard shuttle run test might reconsider the choice of test used to assess anaerobic capacity of their team athletes if the test is shown to be reliable. It is important to verify reliability of the test in order to insure that the test is consistent. In other words, that the test provides same result with repeated measures. A non-reliable test cannot be considered valid either so to insure the test being adequate, the first step is to test the reliability (Thomas, Nelson, & Silverman, 2011).

**Assessment of reliability**

Reliability of a test refers to the consistency or repeatability of the test and is often examined through a test-retest study. The theory of reliability is that all measurements are made with an error so when registering a score, the observed score is composed by the true score component and an error component. Measurement errors are composed by random errors, which are unpredictable variables affecting the test and systematic errors, which are inaccuracies inherited in the system. A higher reliability of a test gives a small difference between the observed and true score. Testing a sample of subjects and then repeating the test several times is the common way to determine the reliability (Vincent & Weir, 2012).

A common metric used for reliability assessment is the intraclass correlation coefficient (ICC), which evaluates the reliability of the same variables measured on repeated occasions. In order to calculate the ICC, total variance is analysed by estimating the true score variance and error variance. The true scores and errors combined represent the observed scores. By dividing the true score variance with the total variance (true score variance plus error variance) an ICC is determined as a ratio. The closer this ratio is 1.0 the lower is the risk for measurement errors.

**Aim**

The aim of this bachelor thesis was to investigate the reliability of the 300-yard shuttle run test. This was performed with a test-retest method.
Research question:
Are the results from the 300-yard shuttle run test identical when performed at two separate test sessions?

Hypothesis:
It is hypothesised that the variance in results of the two sessions are minor and thus, that the 300-yard shuttle run test is reliable.

**Method**

**Subjects**
21 American football players participated in the study. For participation the subjects had to be free from any health problems and musculoskeletal injuries. Test subjects were dissuaded from training the lower extremities the day preceding a test session and were excluded from the study if sickness or injury arose during or between test sessions.

**Test Procedure**
The study consisted of three meetings held in a gymnasium. All sessions were held at scheduled training time, Wednesdays at 19.00 o’clock. One week prior to test session one, a familiarisation meet was held where the test procedure was explained and the 300-yard shuttle run test was performed at submaximal levels. At test session one, all 21 subjects attended. Anthropometric data was taken and the 300-yard shuttle run test was performed. Test session two was held seven days later and the 300-yard shuttle run test was performed a final time. Two subjects dropped out and eight test subjects were absent at session two. Thus a third test session was conducted seven days later in order to collect retest data from remaining subjects, six subjects participated at the third session, one test subject dropped out and one subject was excluded because of illness. Thus, data was collected for the 17 subjects that participated at two sessions.

Prior to the 300-yard shuttle run test a standard warm-up was held and supervised by the coach of the team. The warm-up contained of exercises described below.

- 3 minute jog
The following exercises were executed 10 yards, two times.

- High knees
- Butt kick
- 5 yards side-run with low centre of mass followed by 5 yards acceleration
- Dynamic groin stretch, broad steps
- Walking Lunges
- Walking diagonal toe reach
- "Tip tap toe, spread", three jog steps followed by groin stretch
- 5 yards backwards run followed by turn and forwards run
- 20 meter with three time acceleration
- 20 meter acceleration followed by deceleration

All test subjects were divided into pairs based on similar capacities, which was conducted by the coach. One pair of athletes performed the 300-yard shuttle run test simultaneously. On auditory signal the athletes sprinted the 25-yard line, taped the end of the line with their foot and sprinted back to start line. This was repeated 6 times as fast as possible. Foot contact had to be done at each end of the line when changing direction. No verbal encouragement was used. After the last participant in the pair completed the first trial a 5-minute active rest was recorded. Resting athletes had to stay alert before starting the second trial by walking. The time was recorded to the nearest 10th of a second. With two times recorded of each athlete, the average time was calculated (Gilliam & Marks, 1983).

Two test leaders monitored each athlete’s sprint time and one test leader monitored the rest of the athletes. The same test leaders monitored the subjects sprint time at every bout. All pairs performed the 300-yard shuttle in a systematic order. When the first pair was resting after performing their first bout a second pair performed their first bout and so on. Pairs waiting on their turn to perform the 300-yard shuttle run test attended in tactics exercises on submaximal levels held by the coach. A scheme of the pairs performing the test was conducted in order to have the same order of subject performing the test at every session.
Equipment and material
For the 300-yard shuttle run test a 25-yard (22,86m) long line was measured up. Black scotch tape and cones at each end of the track marked the endings of the line. Stopwatches (Asaklitt, Clas Ohlson) were used for time monitoring of the sprints and rest between bouts. Two stopwatches were used to monitor the time of each test subject and one stopwatch for monitoring the rest period, so a total of five stopwatches were used.

Ethical and Social considerations
The aim of the study and the test procedure was explained verbally and in written to the subjects prior to participation. The verbal information was followed by an opportunity to ask questions. Subjects willing to participate gave their informed consent by signing a form (appendix 1). All data was handled with confidentiality. Only the author, supervisor, examiner and the coach of the team had access to data where participants could be identified. Subjects were informed of their right to drop out of the study without any obligations.

Investigating the reliability of the 300-yard shuttle run test is of interest for practitioners interested in using the test. The consistency of the 300-yard shuttle run test results cannot be guaranteed without a proper quantification of the reliability.

Statistical analyses
Data was entered in Microsoft Excel (2011). Normal distribution of the data was investigated using Shapiro-Wilk's test, which is an appropriate normality test for smaller sample sizes (<20) (Shapiro & Wilk, 1965). According to Shapiro-Wilk's test data was not normally distributed, except for the height and weight data. Therefore all results are presented in median, minimum (min.) and maximal (max.) values (Vincent & Weir, 2012).

To quantify the reliability of the 300-yard shuttle run test the ICC (two-way mixed model, single measure opinion) and 95% confidence interval (CI) was utilised using SPSS (IBM SPSS version 20, Chicago, IL, USA). An ICC of >0.8 was chosen as acceptable level (Weir, 2005; Hopkins, 2000). The ICC was chosen as statistical method instead of a
correlation test due to ICC evaluating the absolute agreement of repeated measures instead of solely assessing the consistency (Streiner & Norman, 2008). The ICC two-way mixed model was utilized because of the study containing a single measure and raters being the only raters of interest, so the variance between raters was not assessed (Shrout & Fleiss, 1979). All graphs and tables were created using Excel.

Results

Subjects’ characteristics are presented in table 1. A total of 17 American football players completed the study. Median age of the subjects was 20 years (min. =18, max= 38 years) with a median weight of 83 kg (min. =67, max. =133 kg). The median height of the test subjects was 184 cm (min. =169, max. =194 cm).

Table 1. Descriptive statistics of the participants (n=17).

<table>
<thead>
<tr>
<th></th>
<th>Median</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>20</td>
<td>18</td>
<td>38</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>83</td>
<td>67</td>
<td>133</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>184</td>
<td>169</td>
<td>194</td>
</tr>
</tbody>
</table>

The subjects had a median result of 66.23 seconds (min. =60.68, max. =86.68 s) at the first session performing the 300-yard shuttle run test. At the re-test session the median result was 65.77 seconds (min. =60.06, max. =91.44 s). The ICC for the test-retest provided a value of 0.97 and a 95% CI of 0.91-0.99.

Table 2. All test subjects (n=17) results in the 300-yard shuttle run test at the test and re-test session presented in time (seconds). The ICC and 95% CI of the repeated measures.

<table>
<thead>
<tr>
<th></th>
<th>Median</th>
<th>Min.</th>
<th>Max.</th>
<th>ICC</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test (seconds)</td>
<td>66.23</td>
<td>60.68</td>
<td>86.68</td>
<td>0.97</td>
<td>0.91-0.99</td>
</tr>
<tr>
<td>Retest (seconds)</td>
<td>65.77</td>
<td>60.06</td>
<td>91.44</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Results of the test and retest session of all subjects is presented in figure 1, showing the within- and between-subject variation.
Discussion

The 300-yard shuttle run test has in previous literature been used for anaerobic capacity assessment of athletes. The test is field-based with light equipment, which enables a larger crowd to utilise the 300-yard shuttle run test. However, in order to assure the assessments done through the 300-yard shuttle test of being consistent the reliability of the test has to be quantified. Therefore, this study aimed to investigate whether the 300-yard shuttle run test provides reliable results at repeated measures.

Result discussion

The median of the test (66.23, min. =60.68, max. =86.68 s) and retest (65.77, min. =60.68, max. =86.68 s) sessions presented a small difference between sessions. Largest variation is showed in the maximal value, which is discussed further in the method discussion. An ICC value of 0.97 was conducted for this test-retest study, meaning that an estimated 97% of the observed score variance is due to the true score variance and 3% due to error variance. According to the 95% CI, the true ICC value of a larger population is
expected to fall within 0.91-0.99. An ICC>0.8 is considered high (Vincent & Weir, 2012; Hopkins, 2000). However, the ICC is influenced by sample size and between-subject variability (Weir, 2005). Therefore an ICC>0.8 is not the enough in order to determine the reliability of a test (Hopkins, 2000; Weir, 2005). The ICC value is sensitive for variability of the data therefore the result will be compared with previous studies aiming to reliability test similar RSA-protocols.

Previous studies reliability testing repeated sprint ability tests

Sporis, Ruzic, & Leko (2008) used the 300-yard shuttle run, among other tests to assess improvements in anaerobic capacity of elite soccer players for two different 8-week intervention programs, two years apart. It is also the only study found attempting to quantify the reliability of the 300-yard shuttle run test. This was done with a test-retest method with the sessions incorporated in the intervention study, as mentioned in the background, which is not optimal for a reliability study (Thomas, Nelson, & Silverman, 2011). The test subjects were 18 elite soccer players composing a more homogenic group when compared with the present study. Thus, the reliability of the 300-yard shuttle run test was considered high (ICC=0.93) (Sporis, Ruzic, & Leko, 2008), which is in line with the result of the present study.

Several other studies have included test-retest of RSA-tests using ICC. Gabbett (2010) aimed to develop a game-specific repeated-sprint test for female soccer players. This was done by analysing the elite soccer players movements during a match play in order to construct the game-specific test, which was reability tested by using 19 elite soccer players to perform a test-retest. According to Gabbett (2010) the total sprint time of the repeated-sprint test provided a high reliability (ICC=0.91). The reliability of the running anaerobic sprint test (RAST) was examined by Zagatto, Beck, & Gobatto (2009). For the study, 40 members of the armed force were recruited. Several measures were taken through the test. The total effort time, which is most equal to the score recorded in the 300-yard shuttle run test, recieved a ICC of 0.9. The test was stated to produce results of high reliability (Zagatto, Beck, & Gobatto, 2009). Glaister et al. (2009) tested the reliability of the 40-meter maximal shuttle run test (40-m MST). They also evaluated the learning effect on test-retest result, reliability was therefore tested for test session two and three. Their recruited subjects were 16 sports science students with mixed sports
background. The reability of the mean time for the 40-m MST was stated high (ICC=0.91) (Glaister et al., 2009). All studies mentioned above used test subjects of more homogenic qualities when comparing with the present study. Only Glaister et al. (2009) used test subject without a physically active profession. The magnitude of the ICC is dependent of the variability of the data meaning that larger in-between subject variability provides a higher ICC (Weir, 2005; Hopkins, 2000). An American football team contain players of different fitness profiles, which is in line with the different physical demands within the sport (Vural, Nalcakan, & Zeki Özkol, 2009; Pincivero & Bompa, 1997). This might explain the variance between subjects in the present study.

Zagatto, Beck, & Gobatto (2009) included a larger sample size than the other studies. Random errors within the test subjects become of smaller importance when sample size is larger because of the errors being diminished when more measures are added (Hopkins, 2000). With a sample size of 17 in the present study, within-subject variation might have affected the results. This is discussed further in following section. However the results of the studies mentioned above supports the result of this study, claiming the 300-yard shuttle run test of being reliable because of the similarities of the tests.

**Within-subject variation**

Ten of seventeen subjects improved their 300-yard shuttle run test result from the test to re-test session. Variation in test result due to physical adaptations is doubtful with the present study design. For participating subjects, one bout of the 300-yard shuttle run test took approximately 60-90 seconds to execute. The anaerobic energy pathways, ATP hydrolysis, PCr and anaerobic glycolysis are the predominant energy sources during the first sprints (McArdle, Katch, & Katch, 2010; Glaister, 2005; Girard, Mendez-Villanueva, & Bishop, 2011). Accumulations of free P, H+, lactate, Mg+, ADP, AMP and IMP are expected when sprints are repeated (Allen, Lamb, & Westerblad, 2007; Glaister, 2005; McArdle, Katch, & Katch, 2010; Girard, Mendez-Villanueva, & Bishop, 2011), as well as perturbations of intra- and extracellular Na+ and K+ levels (Fitts, 2008). The changed intramuscular environment during repeated sprints causes impaired muscle contractility, power production and sprint performance (Glaister, 2005; Girard, Mendez-Villanueva, & Bishop, 2011; Brocherie, Girard, & Gregorie, 2015). The performance in the second bout of the 300-yard shuttle test is mainly determined by the restoration of
pH, PCr and ATP levels achieved in aerobic conditions, which is initiated during the 5-minute rest between bouts (Glaister, 2005; Girard, Mendez-Villanueva, & Bishop, 2011; Brocherie, Girard, & Gregorie, 2015).

To improve individual results in the 300-yard shuttle run test, adaptations in aerobic and anaerobic capacity are desired. Physical adaptations take several weeks of specific training to achieve (McArdle, Katch, & Katch, 2010) and is therefore not likely to have affected the result of this study. Between data collection sessions all test subject attended to regular physical exercise aiming to improve physical performance. With only seven or fourteen days between the test and retest session even minor physiological adaptations are unlikely to have been achieved between the test and retest session. The improvements in test results made by the ten subjects are therefore more likely to be due to learning effect.

Other within-subject variability factors such as sleep, nutrition and mind-set, learning effect may have had an impact on the result of this study. The importance of consistency was stressed when verbal information was given to the test subject prior to the study and a familiarisation opportunity was conducted to minimise learning effect. Nevertheless, these are factors hard to control and are further discussed in following section.

**Method discussion**

In previous literature stopwatches are used for time recording of the 300-yard sprint (Baechle & Earle, 2008; Gilliam & Marks, 1983; Semenick, 1984). Sporis, Ruzic, & Leko (2008) used an electronic time keeping device. Stopwatches were used in the present study in order to keep the field-based fashion of the test. Two raters for each subject were used in this study. The recorded time for each bout of each subject was calculated as the mean value of the two raters observed score. Factors such as concentration and reactivity of the raters will affect the results, therefore this method was used in order to minimise random error within the raters. Risk for systematic error was minimised by using two test leaders for measuring the 25-meter sprint distance at both test times and also by using the same stopwatches at every test session.
Common systematic errors associated with the subjects are motivation, fatigue, health and previous practice (Thomas, Nelson, & Silverman, 2011). Participants with impaired health or with injuries were excluded from the study. A familiarisation meet was conducted prior to the study as a strategy to reduce the variable of learning effect. Three subjects were not present at the familiarisation meet but were included in the study because of the simplicity of the 300-yard shuttle run test. With no experience of the 300-yard shuttle run test this might have increased the range of a systematic error (Vincent & Weir, 2012; Thomas, Nelson, & Silverman, 2011). Even if the three subjects were familiar with sprinting there might have been a learning effect considering the need of skill and co-ordination to perform rapid changes of directions at high speed (Glaister et al., 2009).

Motivation of the subjects is an error factor hard to assess and minimise (Vincent & Weir, 2012). Test subject nr. 9 produced the large max. value variance when comparing test and re-test sessions. The subject can be seen as an outlier with larger between- and in between-subject variation than the other subject (figure 1.). The subject was one of three who was absent at the familiarisation meet, for that reason the subject might have over achieved at the first session, this is claimed because of the subject feeling nauseated after the first session. At retest session the subject stated to be unmotivated to perform the test at maximal effort. This might explain the big variance in test and retest result of the test subjects in concern. However, the test subject met the requirements for participation and was therefore not excluded from the study. Future studies should take this scenario into consideration to perhaps enable exclusion of subjects of this nature.

Two subjects discontinued the study after performing the first bout at the first test session, therefore their two pair members performed their second bout alone. These two athletes were paired at test session two to minimise modifications of the test. Seven days later at test session two, eight subjects were absent. A third test session seven days after test session two, was therefore conducted in order to collect data from the eight missing at the second meet. Seven subjects participated at the third test session.

At all test sessions the athletes in line to perform the 300-yard shuttle run test participated in tactics and skill training prior to the test, which possibly affected their
performance. The 300-yard shuttle run test was therefore performed in a specific order. Thus absence of subjects resulted in some bouts being performed by one subject alone, affecting the magnitude test modification. Because of absence of subjects at retest session, the schedule was also disturbed and the time and order of the subjects’ participation in the 300-yard shuttle run test was slightly changed. This may have caused larger within-subject variability because of different fatigue levels prior to the test between the sessions.

Despite all factors mentioned regarding measurement error, the method used in this study can be hypothesised of being equal to what would be expected when practitioners implement the 300-yard shuttle run test. Changes of pairs being done between test sessions, athletes performing the 300-yard shuttle test by themselves, use of stopwatches and perhaps also subject attending in training prior to the test. Therefore the method and result of this study might be of value for practitioners. However this study was performed with American football players as test subjects with large variations in physical capacity, as mentioned above. Future studies should assess the reliability with a group of more homogenic fitness profile in order to reassure the 300-yard shuttle test of being reliable also for sport of smaller variance in physical demands. Reliability does however not guarantee validity. Validity of the 300-yard shuttle test is also for future studies to assess. Future studies using the 300-yard shuttle run test can also expand the variables being examined. Common variables utilized with RSA-tests are fastest sprint time, total accumulated sprinting time and performance decrement (Meckel, Machnai, & Eliakim, 2009; Morcillo et al., 2014). The 300-yard shuttle run test solely presents results as a mean value of total accumulated sprint time of the two bouts (Gilliam & Marks, 1983; Baechle & Earle, 2008). The time difference between bout one and bout two could, for example be an interesting variable to use when assessing recovery capacity of the athlete.

**Conclusion**

The results of this study show that the 300-yard shuttle run test produces high ICC values when testing a sample of American football players at two separate sessions. Therefore the 300-yard shuttle test is proposed as a test providing reliable results.
Future research is however needed to provide if there is any difference when utilising the 300-yard shuttle run test on a subject sample of different characteristics and to assess the validity of the 300-yard shuttle run test.
References


Appendix 1. Informed Consent form

Test-retest of the 300-yard Shuttle

Bakgrund & Syfte
Mitt namn är Hanna Gottlieb, jag studerar Biomedicin – inriktning fysisk träning på Halmstad Högskola. Denna studie görs som examensarbete sista året i utbildningen.

Många lagsporter innehåller korta, explosiva sprinter och snabba riktningsförändringar. För en så bra prestation som möjligt under match krävs därför att spelarna utvecklar sin explosivitet, uthållighet och kvickhet. Det är också fördelaktigt att emellanåt testa sig för att utvärdera effekten av en periodens träning.

Ett test som har använts på amerikanska fotbollsspelare är 300-yard shuttle run test. Upplägget av testet ser ut på följande sätt (se bild 1.):
- Två parallella 25-yard (22,86m) långa linjer markeras med start och stop.
- Två idrottare med likvärdig prestation placerar sig vid start linje.
- Vid ljudsignal börjar de sprinta den uppmätta sträckan. Vid slutet av linjen ska de nudda markeringen med sin fot och sprinta tillbaka samma sträcka.
- Detta upprepas 6 gånger följt av en 5 minuters vila.
- Efter 5 minuters vila upprepas ovanstående sprint.
- Tiden för dessa två sprinter registreras.

Syftet med denna studie är att utvärdera testets reliabilitet, med andra ord om testet vid upprepade försök, tätt in på varandra ger samma resultat.

Bild 1.

![Testing Protocol 300-yard shuttle run](image)

(Gilliam & Marks, 1983)

Förfrågan om deltagare?
Du har blivit omedd att delta i denna studie då du är aktiv i amerikansk fotboll.
Hur går studien till?

Fördelar
Som deltagare får du information om din sprinthastighet, uthållighet och kvickhet.

Hantering av data och sekretess
Endast författare, handledare, examinator och tränare har tillgång till personuppgifter och resultat. Samtliga testpersoner kommer vara anonyma när resultatet presenteras. Du som deltagare har rätt att ta del av undersökningsresultatet. Din tränare kommer också få ta del av testresultaten för att i fortsättningen kunna utvärdera träningsprogram.

Frivillighet
Du har rätt att närsomhelst avbryta ditt deltagande i studien utan att ange anledning.

Information om studiens resultat
Resultatet av studien kommer presenteras våren 2015 som kandidatuppsats.

Tack!
Hanna Gottlieb

Kontaktinformation
Hanna Gottlieb
076-8209843
hangot12@student.hh.se

Informert samtycke
- Jag har tagit dela av muntlig och skriftlig information om forskningsstudien.
- Jag bekräftar samtycke till att delta i studien och vet att deltagande är frivilligt.
- Jag är medveten om att jag när som helst och utan förklaring kan avbryta mitt deltagande i studien.
- Jag tillåter att mina personuppgifter hanteras enligt den information jag tagit del av.

.............................
Datum

..........................................................
Författares namnteckning Namn förtydligande

..........................................................
Deltagares namnteckning Namn förtydligande
Hanna Gottlieb
B.Sc Exercise Biomedicine
NSCA-CPT